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F1B
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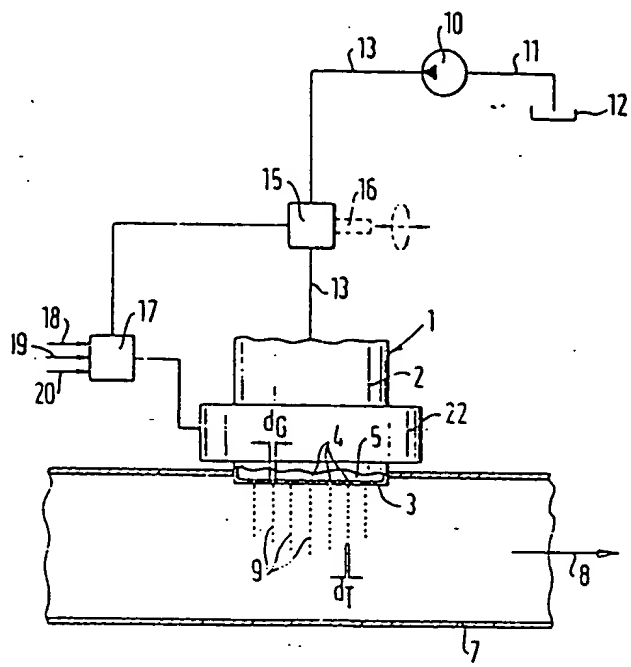
(54) Ultrasonic atomiser

(57) An ultrasonic atomiser (1) for liquid comprises an atomiser housing (2) to which liquid is fed under pressure by a pump (10). The housing (2) has spray openings (4) of equal diameter, and the liquid jets issuing from the openings (4) are stimulated to give uniform diameter droplets by an ultrasonic vibrator (22). For the formation of droplets of equal diameter (d_T), the vibrator (22) is excited by an electronic control device (17) into vibrations ranging from a minimum equal to the product of the diameter (d_G) of the opening (4) and pi (π), and a maximum equal to six times the amount of the minimum wavelength. The atomiser can be used to disperse fuel in and i.c. engine.



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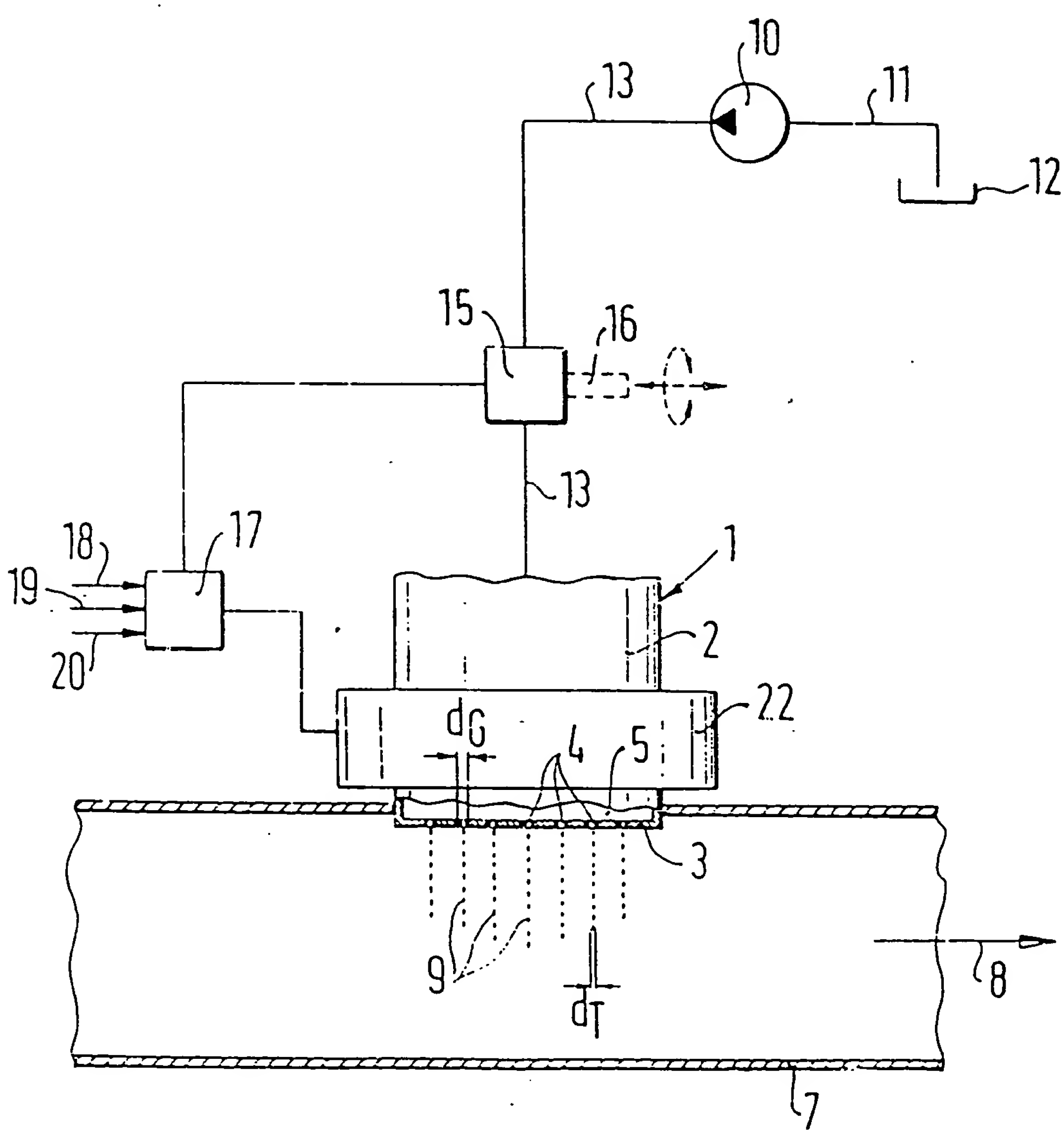

vibrator 22 can, of course, also be integrated in the housing 2 and preferably lies in the region of the end face 3. The fuel, disposed under pressure in the chamber 5, issues as fine jets through the openings 4 and is stimulated to disintegrate into droplets by the vibrator 22, in particular into droplets of equal diameters d_T. Mono-disperse droplets thus enter the induction duct 7 and intermix with the inducted air to form a homogenous fuel-air mixture. The drive of the vibrator 22 takes place through the control device 17 in dependence on the engine operating magnitudes and produces vibrations with such a wavelength λ so to effect the desired disintegration of the fuel jets. The permissible range of the wavelengths λ of the vibrations for generation of droplets of equal diameter lies between a minimum wavelength λ_{min} and a maximum wavelength λ_{max}. The minimum wavelength is determined by the product of the diameter d_G of the openings 4 and pi (π) and the maximum wavelength amounts to six times the product of the diameter d_G and pi (π), thus six times the amount of the minimum wavelength. The smallest diameter d_T of the monodisperse droplets results from the minimum wavelength λ_{min} of the ultrasonic vibrator 22.

The fuel volume $\dot{V}$ passed through a spray opening 4 per unit time can be determined by the following equation:

$$\dot{V} = \pi/4 \cdot d_G^2 \cdot V_G,$$

wherein v_G is the mean speed of the fuel in the opening 4. This mean speed depends on the pressure gradient between the chamber 5 and the induction duct 7.

The wavelength λ of the vibration imposed on the fuel jet issuing from the opening 4 amounts to:

$$\lambda = v_G/f_G,$$

wherein f_G is the excitation frequency of the vibrator 22.

The diameter d_T of the fuel droplets is given by

$$d_T = \sqrt[3]{6/\pi \cdot \dot{V}/f_G}.$$

Under consideration of the two formulae mentioned above, the diameter of the fuel droplets is given by these as

$$d_T = \sqrt[3]{1.5 d_G^2 \cdot \lambda}.$$

Apart from the described use of the atomiser 1 for fuel preparation in an internal combustion engine, many other uses are possible, for example fine enamelling operations may be able to be performed better than with conventional spraying and sprinkling methods, air moistening in air-conditioning installations may be able to be improved, and so forth.

CLAIMS

1. An ultrasonic atomiser for liquid, comprising a chamber to receive liquid under pressure and provided with a plurality of spray openings of substantially equal diameter for issue of the liquid in jets, and an ultrasonic vibrator operable to induce vibrations of such a wavelength in the issuing liquid jets as to effect disintegration of the jets thereby to cause droplets of substantially equal diameter to be formed.

2. An ultrasonic atomiser as claimed in claim 1, wherein the wavelength is equal to at least the product of pi and the first-mentioned diameter.

3. An ultrasonic atomiser as claimed in claim 2, wherein the wavelength is equal to at most six times said product.

4. An ultrasonic atomiser substantially as hereinbefore described with reference to the accompanying drawing.

5. A fuel injection system for an internal combustion engine, the system comprising an atomiser as claimed in any one of the preceding claims for feeding fuel into an induction duct of such engine and atomising the fuel to enable formation of a fuel-air mixture in such duct.

6. A system as claimed in claim 5 and substantially as hereinbefore described with reference to the accompanying drawing.

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SPECIFICATION

Ultrasonic atomiser

The present invention relates to an ultrasonic atomiser for liquid.

Ultrasonic atomiser nozzles are known and used for, for example, injection of fuel in internal combustion engines, ultrasonic vibrations being created to break up the fuel jet issuing from the nozzles into small droplets. In that case, however, there is the disadvantage that the diameters of the liquid droplets produced by the nozzle are scattered over a wide range, which is advantageous in many cases. For example, in the case of use of this known ultrasonic atomiser nozzle for fuel supply in an internal combustion engine it is disadvantageous that the different droplet sizes preclude preparation of an optimum fuel-air mixture, with the result that a non-uniform mixture distribution over the individual cylinders of the engine takes place. Thus, dyestuffs, additives and the like often cannot be atomised by the known ultrasonic atomiser nozzles in desired manner with equal droplet sizes and uniform distribution of the liquid concerned.

According to the present invention there is provided an ultrasonic atomiser for liquid, comprising a chamber to receive liquid under pressure and provided with a plurality of spray openings of substantially equal diameter for issue of the liquid in jets, and an ultrasonic vibrator operable to induce vibrations of such a wavelength in the issuing liquid jets as to effect disintegration of the jets thereby to cause droplets of substantially equal diameter to be formed.

An ultrasonic atomiser embodying the present invention may have the advantage that the generation of even large quantities of liquid as an aersol with monodisperse droplets, i.e. droplets of equal diameter, is ensured in simple mode and manner. Consequently, a liquid mist can be produced for diverse fields of use in that the individual liquid droplets have substantially equal diameters. An atomisation of that kind is desirable for, for example, production of a homogenous fuel-air mixture in a mixture-forming unit of an internal combustion engine in order to produce a homogeneous and thereby well prepared fuel-air mixture and to ensure a uniform fuel distribution over the individual engine cylinders.

Through choice of the wavelength of the vibrations in a particular range between a minimum and a maximum wavelength, under the condition of monodisperse droplet formation, the droplet diameter can be varied in order to meet specific requirements.

In an advantageous embodiment, the smallest diameter of the droplets results when the wavelengths of the vibrations produced by the vibrator correspond to at least the product of the diameter of the spray openings and pi. The largest diameter of the monodisperse droplets results in advantageous manner when the wavelengths of the vibrations produced by the ultrasonic vibrator correspond to at most six times the product of the diameter of the spray openings and pi.

The use of the atomiser for atomisation of fuel in the formation of a fuel-air mixture for an internal combustion engine is particularly advantageous, since not only is the formation of a homogeneous fuel-air mixture ensured, but also as equal as possible a distribution of the flue over the individual cylinders of the engine can be achieved. This may reduce fuel consumption and also the production of noxious components in the engine exhaust gas.

An embodiment of the present invention will now be more particularly described by way of example only with reference to the accompanying drawing, the single figure of which is a schematic diagram of a fuel injection system incorporating an atomiser embodying the invention.

Referring now to the drawing there is shown an ultrasonic atomiser which, in this embodiment, serves for the atomisation of fuel for the formation of a fuel-air mixture in an internal combustion engine. For this purpose, the ultrasonic atomiser nozzle 1 comprises a housing 2 in one end face 3 of which are provided several spray openings 4 having an equal diameter d_c. The openings 4 lead outwardly from a pressure chamber 5 in the interior of the housing 2 and are produced by, for example, Laser beam drilling. The required number of the openings 4 is determined by the quantity of liquid - in the present embodiment the quantity of fuel - which shall maximally be sprayed or atomised. For the formation of a homogeneous fuel-air mixture to be fed to the engine, the atomiser 1 is so arranged at or in an induction duct 7 of the engine that the inducted air flowing in arrow direction 8 intermixes intensively with fuel droplets 9 issuing from the atomiser. The supply of the atomiser 1 with fuel takes place from a fuel pump 10, which by way of a suction duct 11 draws fuel from a fuel tank 12 and conveys it under pressure to a fuel supply duct 13 which leads to the atomiser. A fuel metering element 15, which in known manner contains a fixed or variable throttle point actuable electromagnetically or mechanically by way of an actuating member 16 in dependence on engine operating magnitudes, can be arranged in the duct 13 between the atomiser and the fuel pump or integrated in the atomiser. The actuating member 16 of the fuel metering element 15 can be displaced axially or turned in known manner, for example through a throttle flap, or air-measuring device, arranged in the induction duct 7. In the case of electromagnetic actuation of the element 15, the drive is effected through an electronic control device 17, to which are fed engine operating magnitudes in the form of electrical signals, for example engine load 18, inducted air quantity 19, temperature 20 and the like.

Placed on the atomiser 1 is an ultrasonic vibrator 22, which is constructed as, for example, a piezoceramic vibrator and is drivable by the device 17 in dependence on engine operating magnitudes. The